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# Effects of Thinning Pole-Sized Lodgepole Pine on Understory Vegetation and Large Herbivore Activity in Central Colorado

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### **Abstract**

Thinning treatments to control growing stock levels (GSL) in a stand of 65-year-old lodgepole pine enhanced understory plant production, cover, and forage quality 5 years after treatment. Plant use and large herbivore activity also increased in the more heavily thinned blocks.

# **Effects of Thinning Pole-Sized Lodgepole Pine on Understory Vegetation and Large Herbivore Activity in Central Colorado**

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# Effects of Thinning Pole-Sized Lodgepole Pine on Understory Vegetation and Large Herbivore Activity

Glenn L. Crouch

## MANAGEMENT IMPLICATIONS

Overstocked, immature forests are relatively poor habitat for big game and poor producers of forage for livestock. Thinning 65-year-old lodgepole pine to relatively wide spacing increased forage production, quality, and availability. Treatment costs probably were offset by value returned from posts, poles, and firewood; further returns could accrue from the residual stand if expected increases in growth occur. Additional gains in understory growth are of economic value only if the forage produced is utilized by large herbivores. Such use must take place during the growing season, because most lodgepole stands are snow-bound during winter.

## INTRODUCTION

Lodgepole pine (*Pinus contorta*)<sup>2</sup> is a prominent timber species of subalpine forests in the central Rocky Mountains. Stands of various ages grow under many different environmental conditions. Most current pure or nearly pure stands of lodgepole pine have resulted from wildfire or logging, or some combination of the two in stands that may have been dominated by other, more stable plant associations (Alexander et al. 1983).

Many lodgepole pine stands tend to be grossly overstocked; others have more moderate stocking but still contain too many trees for optimum timber production. Because of dense stocking, many pole-sized stands in the central Rockies are poor producers of forage for livestock and big game. Also, they are only moderately useful as habitats for birds and other wildlife species, because most have little within-stand variety in canopy or understory characteristics (Buttery and Gillam 1984).

Most lodgepole stands have considerable snow cover and are inaccessible to mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus canadensis*) in the winter. Low temperatures and snow preclude occupancy by other resident wildlife species, except those adapted to severe winters.

The objective of this study was to document responses of understory vegetation to several levels of stocking control, and to evaluate effects of the measured changes on activities of large herbivores using the thinned sites.

## STUDY AREA

A contiguous, 900-acre stand of pole-sized, 65-year-old lodgepole pine grows on the Fraser Experimental Forest near Fraser, Colo., in the central Rockies (Alexander et

<sup>2</sup>Plant nomenclature generally corresponds with Harrington (1954).

al. 1985). This stand resulted from logging an old-growth forest of Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), and lodgepole pine about 1910. Sporadic, patchy wildfires swept the area after logging, providing ideal conditions for lodgepole pine regeneration.

By 1975, this stand averaged between 1,000 and 2,000 lodgepole pine stems per acre, with a mean tree height slightly more than 50 feet (table 1). A few aspen trees averaging about the same height were widely scattered through the lodgepole pine stand.

This study was conducted on a nearly level portion of the stand at an elevation of 8,800 feet. Soils are loams and gravelly loams on deep, cobbly glacial outwash (Retzer 1962). Winters are long, cold, and snowy, and summers are cool and moist. Annual temperatures averaged  $35 \pm 0.3^\circ\text{F}$ , and precipitation  $24.2 \pm 1.4$  inches at an on-site gauging station during the study period. About two-thirds of the annual precipitation falls as snow from October through May.<sup>3</sup>

The experiment on which this study was superimposed was designed to control growing stock levels (GSL) of lodgepole pine so that stocking would approximate basal areas of 40, 80, and 120 square feet per acre when the average tree diameter (d.b.h.) was 10 inches in each stocking level.

Overstory vegetation was overwhelmingly lodgepole pine, although a few seedlings and saplings of Engelmann spruce and subalpine fir were present. Understory vegetation was low-growing and about evenly divided in most areas between woody plants, mostly *Vaccinium scoparium*, with lesser amounts of *V. myrtillus*, and several species of forbs. Sedges were reasonably well distributed through the area; but grasses were very scarce.

Vegetation on most areas resembled the *Pinus contorta*/*Vaccinium scoparium* and *P. contorta*/*Carex geyeri* plant associations described by several authors, including Wirsing and Alexander (1975) and Hess (1981). In the absence of fire or logging, the site probably will succeed to a forest dominated by Engelmann spruce and subalpine fir.

The area serves as growing-season range for mule deer and elk, and as seasonal or year-round habitat for several species of birds and smaller mammals (Alexander et al. 1985). Cattle grazed on the area during the summer.

## METHODS

The basic treatments to control growing stock levels, replicated in time and space, were applied in 1976, 1977,

<sup>3</sup>Data on file at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Table 1.—Overstory stand characteristics before and after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.<sup>1</sup>

Growing stock levels	Dominant trees			Number of trees per acre		Basal area (ft <sup>2</sup> /acre)		Canopy cover (percent)	
	Heights (ft.)	Ages (yrs.)	Site index	Before	After	Before	After	Before	After
Control	53 ± 1	66 ± 4	78 ± 1	1,300 ± 107	1,300 ± 107	154 ± 4	154 ± 4	67 ± 3	67 ± 3
120	51 ± 1	67 ± 4	78 ± 2	2,070 ± 370	497 ± 13	155 ± 8	73 ± 2	74 ± 3	53 ± 3
80	54 ± 2	67 ± 4	77 ± 3	1,296 ± 252	279 ± 3	158 ± 20	58 ± 1	66 ± 3	43 ± 3
40	52 ± 2	67 ± 4	79 ± 3	1,747 ± 89	138 ± 5	160 ± 16	30 ± 1	71 ± 4	17 ± 3

<sup>1</sup>Mean ± SE. Data on file at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

and 1978. Each year, one set of square, one-half-acre blocks was thinned to basal areas averaging 30, 58, and 73 square feet per acre, which will correspond to GSL 40, 80, and 120. In addition, an unthinned control block of the same size was established each year at the site of each set of treatments. Merchantable material consisting of posts and poles was removed by the logger, and felled smaller trees and tops were hand-carried from the blocks shortly after thinning was completed.

Inventories of understory vegetation were conducted on four parallel, 130-foot lines located about 30 feet apart, with the outside lines about 30 feet from the block edges.

Plant production was determined by clipping current growth to a 5-foot height, within 10, 1-foot quadrats spaced about 15 feet apart along each sampling line (40 plots per block). Woody plants, graminoids, and forbs were sacked separately, were weighed green in the field, and later were oven-dried at 60°C to determine moisture content.

Plant cover by species was estimated by 10% increments in 40, 1- x 2-inch rated microplots spaced about 3 feet apart on each sampling line (120 microplots per block) (Morris 1973).

Production and cover were measured near the peak of each growing season during the second or third week of August each year, from the year before thinning through the fifth year after thinning was completed. These years were 1976–1982 for the first replicate, 1977–1983 for the second, and 1978–1984 for the third replicate. Vegetation was not sampled in the year of thinning.

Effects of thinning on the quality of understory as potential forage were evaluated after thinning by comparing moisture, crude protein content, and dry matter digestibility, using analytic procedures similar to those used by Regelin et al. (1974). Rumen inoculum from a domestic cow, fed grass hay, was used in digestibility determinations.

### Plant Utilization

Feeding incidence on understory plants by large herbivores was inventoried in the third, fourth, and fifth years after thinning. For this, 30, 1-foot quadrats were examined in the fall each year in each block. Quadrats were located 15 feet apart along three lines equally spaced across each block (30 plots per block). Treatment

effects on frequency of use were determined from data obtained by dividing the number of plots in which a plant species was utilized, by the number of plots in which that species occurred.

### Herbivore Activity

Elk, deer, and cattle activity was monitored in the third, fourth, and fifth years after thinning on each block, from fecal group counts made on four, 4- x 110-foot transects, located in the same manner as the four plant sampling lines described previously.

### Data Analysis

Analysis of variance ( $P = 0.05$ ) was used to test for annual and periodic differences for each measured attribute. Tukey's test was used to separate means where appropriate (Snedecor 1961). Linear regression ( $P = 0.05$ ) was used to test for significance of time-trends after thinning. The quantitative statements greater or lesser, increases or decreases, etc., used in the following sections indicate that values reported are significantly different, or that time-trend relationships are significant ( $P = 0.05$ ).

## RESULTS

Pre- and postthinned overstory characteristics are summarized in table 1, and representative plots of each treatment in the first year after thinning are shown in figures 1 to 4. No characteristic was different among GSL treatments before thinning. After thinning, numbers of trees, basal areas, and canopy coverages were lowest on GSL 40 plots and intermediate on GSL 80 and 120 plots. Mean diameter was greater on GSL 40 and 80 plots than on control and GSL 120 plots.

### Plant Production

#### Total

Pretreatment plant production averaged about 300 pounds per acre among all treatments (table 2). Shrubs and forbs comprised about 95% of the total before and





Figure 1.—Control block.



Figure 2.—GSL-40 block before slash removal.

after treatment. Understory growth on the more heavily thinned GSL 40 and 80 blocks increased over the 5-year posttreatment period, but not on the unthinned and GSL 120 blocks. Yearly gains were consistent only on GSL 40 blocks. Total production increased by 28% and 21%, respectively, on GSL 40 and 80 blocks, but was unchanged on those assigned control and GSL 120 treatments.

### Woody Plants

Woody plants provided more than 50% of understory biomass over the 5-year study period on unthinned blocks (table 2). Shrubs also dominated overall production before and after treatments at GSL 120. However, mean annual production was not different before and after thinning on control and GSL 80 blocks, and declined at GSL 40. Posttreatment gains were consistent from year to year at GSL 40, even though initial shrub production was markedly reduced in the years immediately after thinning.

### Graminoids

Graminoid production consisting mainly of sedges was low in all years among all treatments (table 2). Treatment



Figure 3.—GSL-80 block after slash removal.



Figure 4.—GSL-120 block after slash removal.

effects were detected only at GSL 40, where mean production was greater after than before thinning.

### Forbs

Forbs made up more than 40% of pretreatment plant production on all blocks. These plants showed large mean annual gains after thinning at GSL 40 and 80, but no change on control and GSL 120 blocks. Annual increases in forb production were consistent only at GSL 40.

### Plant Cover

#### Total

Total plant cover averaged about 40% on all blocks before thinning (table 3). Shrubs, graminoids, and forbs contributed 20%, 1%, and 19%, respectively, to the total. All species encountered were perennials. Thinning was followed by initial reductions in total cover; but average annual posttreatment amounts were greater at GSL 40 and 80, because total plant cover increased consistently after thinning (table 3). Cover on controls and GSL 120 blocks was unchanged.

Table 2.—Dry weight understory plant production (pounds/acre) before and after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.

Growth form, GSL, and basal area (ft <sup>2</sup> /acre)	Before thinning <sup>1</sup>	Years after thinning					Mean of 5 years after thinning <sup>1</sup>
		1	2	3	4	5	
Woody plants							
Control (154)	152 ± 15a	137	160	173	186	171	165 ± 15a
120 (73)	191 ± 24a	141	176	272	210	293	218 ± 13a
80 (58)	136 ± 10a	78	121	151	121	181	130 ± 12a
40 (30) <sup>2</sup>	157 ± 27a	82	85	109	140	184	120 ± 13a
Graminoids							
Control (154)	25 ± 7a	36	24	28	29	18	27 ± 6a
120 (73)	6 ± 2a	11	8	2	8	4	7 ± 2a
80 (58)	7 ± 3a	8	7	24	18	26	17 ± 7a
40 (30) <sup>2</sup>	6 ± 2b	11	12	41	42	42	30 ± 4a
Forbs							
Control (154)	106 ± 12a	124	79	87	81	111	96 ± 6a
120 (73)	126 ± 23a	115	78	90	118	115	103 ± 10a
80 (58)	128 ± 11b	153	145	259	220	215	198 ± 13a
40 (30) <sup>2</sup>	154 ± 21b	177	236	324	367	359	292 ± 19a
Total							
Control (154)	283 ± 23a	297	263	288	296	300	288 ± 13a
120 (73)	323 ± 59a	267	262	364	336	412	328 ± 9a
80 (58)	271 ± 27b	239	273	434	359	422	345 ± 21a
40 (30) <sup>2</sup>	317 ± 51b	270	333	474	549	585	442 ± 26a

<sup>1</sup>Within growth form and GSL values ± SE, before and after thinning followed by the same letter are not significantly different ( $P = 0.05$ ).

<sup>2</sup>Production is significantly correlated with years after thinning ( $P = 0.05$ ).

Table 3.—Percent understory cover by growth form before and after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.

Growth form, GSL, and basal area (ft <sup>2</sup> /acre)	Before thinning <sup>1</sup>	Years after thinning					Mean of 5 years after thinning <sup>1</sup>
		1	2	3	4	5	
Woody plants							
Control (154)	21.5 ± 6.5a	22.5	23.8	23.6	24.3	22.2	23.3 ± 1.1a
120 (73) <sup>2</sup>	24.4 ± 4.7a	21.5	25.3	30.0	30.4	32.6	28.0 ± 1.7a
80 (58) <sup>2</sup>	16.8 ± 3.0a	11.7	14.8	17.8	16.5	20.9	16.3 ± 1.7a
40 (30) <sup>2</sup>	18.9 ± 3.1a	8.9	12.7	15.1	16.9	16.5	14.0 ± 0.8a
Graminoids							
Control (154)	2.3 ± 0.7a	3.3	3.9	3.0	4.0	2.1	3.3 ± 0.5a
120 (73)	0.7 ± 0.3a	0.6	1.1	1.6	1.3	1.6	1.2 ± 0.2a
80 (58)	0.8 ± 0.2b	1.3	3.1	2.1	2.7	2.6	2.4 ± 0.3a
40 (30) <sup>2</sup>	0.7 ± 0.2b	1.4	2.5	3.8	4.3	5.7	3.5 ± 0.4a
Forbs							
Control (154)	17.8 ± 1.6a	18.9	14.0	18.9	16.4	21.7	18.0 ± 1.0a
120 (73)	16.1 ± 1.0a	14.6	12.3	16.0	16.5	19.3	15.7 ± 0.9a
80 (58)	21.1 ± 3.6a	22.4	22.4	27.3	26.2	26.9	25.0 ± 1.1a
40 (30) <sup>2</sup>	22.8 ± 2.1b	24.2	28.4	35.4	35.7	43.2	33.4 ± 1.5a
Total							
Control (154)	41.6 ± 3.7a	44.7	41.7	45.5	44.7	46.0	44.5 ± 1.3a
120 (73) <sup>2</sup>	41.2 ± 5.0a	36.7	38.7	47.6	48.2	53.5	44.9 ± 1.8a
80 (58) <sup>2</sup>	38.7 ± 6.1b	35.4	40.3	47.2	45.4	50.4	43.7 ± 1.9a
40 (30) <sup>2</sup>	42.4 ± 2.5b	34.5	43.6	54.3	56.9	65.4	50.9 ± 1.9a

<sup>1</sup>Within growth form and GSL values ± SE, before and after thinning followed by the same letter are not significantly different ( $P = 0.05$ ).

<sup>2</sup>Production is significantly correlated with years after thinning ( $P = 0.05$ ).



## Woody Plants

All of the 12 shrub species recorded were found on all study sites. *Vaccinium* spp. was the dominant shrub, and in fact, the dominant overall plant species, averaging 15% cover among pretreatment blocks (table 4). Cover of *Vaccinium* spp. declined immediately after treatments but increased consistently thereafter at all levels of thinning. After 5 years, the mean annual cover of *Vaccinium* spp. was not different from pretreatment levels, except at GSL 40 where it remained low. No differences in cover before and after thinning were detected in any other shrub species at any GSL.

## Graminoids

Graminoids were sparse. Seven species were identified; but only *Carex* spp., comprising more than 90% of the total graminoid cover, and *Poa pratensis*, contributing about 5%, were sufficiently common to permit analyses (table 4).

Overall, thinning to GSL 40 resulted in small but consistent increases in graminoid cover over the 5-year study. Mean annual cover also was greater after than before thinning on GSL 40 and 80 blocks. No changes were observed on controls or at GSL 120. Mean annual cover of *Carex* spp. was greater after than before thinning at GSL 40 and 80; but gains were not consistent from year to year. *Poa pratensis* increased consistently, and in mean annual cover at GSL 40 (table 4).

## Forbs

Fifteen forb species were recorded during inventories. Of these, nine had sufficient cover to permit analyses (table 4). *Happlopappus parryi* was the most common forb; but no species was dominant. Thinning had no initial effect on forb cover; but consistent increases occurred through the study period at GSL 40 and 80. In addition, forb cover was greater after, than before thinning at GSL 40 (table 3).

Among individual species, mean annual cover of *Fragaria ovalis* was greater after, than before thinning, and increased consistently from year to year at GSL 40. Cover of *Lupinus argenteus* increased consistently after treatment at GSL 40, 80, and 120, and its cover was greater after than before thinning at GSL 40 and 80 (table 4).

## Forage Quality

Compositing of understory plant samples precluded the opportunity to determine if changes in the monitored characteristics after thinning resulted from changes within growth form, or in relative proportions of shrubs, graminoids, and forbs.

Moisture content of understory vegetation averaged about 60% and was unchanged over the 5-year study period on the controls and at GSL 120 (table 5). Moisture content increased consistently at GSL 40 and 80, averaging 68% and 66%, respectively. Although not determined

quantitatively, it is likely that these gains resulted from increases in proportions of succulent forbs. Similar changes were noted after logging in a nearby mature subalpine forest (Crouch 1985).

Over the 5-year period, crude protein content was unchanged on control and GSL 120 blocks, averaging about 9.4%, but increased consistently at GSL 40 and 80 (table 5). These gains appeared to result from increases in nitrogen amounts in the plants themselves, as well as changes in proportions of growth form in the composited vegetation.

In vitro digestibility was unchanged in controls and at GSL 120, averaging about 37% over 5 years (table 5). Increases in proportions of highly digestible forbs appeared responsible for the consistent annual increases in digestibility of samples from GSL 40 and 80 treatments (Crouch 1985).

## Plant Utilization

Incidence of plant utilization by herbivores was very low during the first 2 years after thinning, and treatment effects could not be evaluated. Evidence of use, however, increased in the later years, and results of utilization inventories are shown in tables 6 and 7. Herbivore use was recorded on 19 of the 39 species found in the sample quadrats.

Among all species and treatments, incidence of browsing increased as basal area decreased, from 19% in the open GSL 40 blocks to 8% in the controls. Incidence of browsing was most frequent on forbs (9%), intermediate among graminoids, and lowest on woody plants (5%).

## Herbivore Activity

Herbivore activity based on fecal group presence was too low for evaluation before, and in the first 2 years after treatments, but increased thereafter. Results of fecal group inventories from the final 3 years are shown in table 8. Using numbers of groups as indices of activity, deer and cattle showed preferences for the more heavily thinned blocks; but elk showed no preference among GSL categories.

## DISCUSSION

Studies in the western states and Canada have documented increases in understory production following partial or, more often complete, removal of tree overstories (Ffolliott and Clary 1982, Bartlett and Betters 1983).

In lodgepole pine, Trappe and Harris (1958) in northeastern Oregon, Dodd et al. (1972) in British Columbia, and Edgerton et al. (1975) in central Oregon, all studied overstory-understory relationships. Dealy (1975) reported on understory cover after thinning in a 47-year-old stand in central Oregon. More recently, Austin and Urness (1982) measured understory response to thinning

Table 4.—Percent understory cover of major species, before and after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.

Growth form, species, GSL, and basal area (ft <sup>2</sup> /acre)		Before thinning <sup>1</sup>	Years after thinning					Mean of 5 years after thinning <sup>1</sup>
			1	2	3	4	5	
Woody plants								
<i>Vaccinium</i> spp.								
Control	(154)	15.9 ± 1.6a	15.5	16.9	17.9	16.5	17.0	16.8 ± 0.8a
120	(73) <sup>2</sup>	18.8 ± 4.0a	11.5	17.5	21.4	23.1	26.2	19.9 ± 1.4a
80	(58) <sup>2</sup>	12.6 ± 1.6a	5.3	7.4	10.6	10.5	16.7	10.1 ± 1.3a
40	(30) <sup>2</sup>	14.4 ± 3.0b	3.3	5.9	7.9	9.6	10.5	7.4 ± 0.9a
<i>Rosa</i> sp.								
Control	(154)	2.4 ± 0.8a	2.9	3.2	2.7	2.8	2.6	2.8 ± 0.3a
120	(73)	2.4 ± 0.9a	3.1	1.9	2.5	2.7	2.6	2.6 ± 0.3a
80	(58)	2.0 ± 0.5a	3.3	3.6	3.5	2.0	2.4	3.0 ± 0.4a
40	(30)	2.0 ± 0.5a	2.8	2.3	3.2	2.4	2.8	2.7 ± 0.2a
<i>Shepherdia canadensis</i>								
Control	(154)	1.0 ± 0.4a	0.6	0.7	0.6	1.2	0.6	0.7 ± 0.2a
120	(73)	0.8 ± 0.3a	1.9	1.4	1.2	1.1	0.7	1.3 ± 0.2a
80	(58)	0.5 ± 0.2a	0.6	0.6	0.9	0.7	0.4	0.6 ± 0.2a
40	(30)	0.9 ± 0.4a	0.5	1.6	1.1	1.1	0.6	1.0 ± 0.2a
<i>Arctostaphylos uva-ursi</i>								
Control	(154)	0.8 ± 0.4a	1.3	0.6	1.1	1.3	0.6	1.0 ± 0.2a
120	(73)	1.0 ± 0.1a	1.5	1.2	0.9	1.3	0.8	1.1 ± 0.2a
80	(58)	0.7 ± 0.3a	0.4	0.9	1.7	1.4	0.6	1.0 ± 0.2a
40	(30)	0.8 ± 0.4a	0.9	1.0	1.6	1.9	1.8	1.4 ± 0.3a
<i>Juniperus communis</i>								
Control	(154)	0.8 ± 0.3a	1.3	0.6	1.1	1.3	0.6	1.0 ± 0.2a
120	(73)	0.9 ± 0.4a	0.9	0.6	1.5	1.0	0.6	0.9 ± 0.2a
80	(58)	0.5 ± 0.2a	0.7	1.0	0.9	1.0	0.8	0.9 ± 0.2a
40	(30)	0.8 ± 0.4a	0.4	0.5	0.9	0.5	0.5	0.6 ± 0.1a
Graminoids								
<i>Carex</i> spp.								
Control	(154)	2.1 ± 0.3a	2.9	3.8	2.7	3.8	2.0	3.0 ± 0.5a
120	(73)	0.6 ± 0.4a	0.5	1.1	1.4	0.6	0.7	0.9 ± 0.2a
80	(58)	0.6 ± 0.2b	0.7	2.1	1.2	2.0	1.7	1.5 ± 0.2a
40	(30)	0.6 ± 0.2b	1.1	2.0	1.1	1.8	2.4	1.7 ± 0.3a
<i>Poa pratensis</i>								
Control	(154)	0.1 ± <0.1a	0.2	0.1	0.3	0.2	0.1	0.2 ± <0.1a
120	(73)	0.1 ± <0.1a	0.1	0.0	0.2	0.5	0.3	0.2 ± <0.1a
80	(58)	0.1 ± <0.1a	0.4	0.6	0.4	0.3	0.4	0.4 ± 0.1a
40	(30) <sup>2</sup>	0.1 ± 0.0b	0.2	0.4	1.0	1.2	1.2	0.8 ± 0.2a
Forbs								
<i>Happlopappus parryi</i>								
Control	(154)	6.4 ± 1.0a	6.3	4.1	3.8	4.9	5.4	4.9 ± 0.5a
120	(73)	6.2 ± 1.3a	5.4	3.6	6.3	5.4	6.3	5.4 ± 0.6a
80	(58)	7.4 ± 1.3a	4.3	5.3	8.9	8.1	7.9	6.9 ± 0.5a
40	(30)	10.4 ± 1.1a	9.1	10.7	11.5	9.9	14.9	11.2 ± 0.7a
<i>Fragaria ovalis</i>								
Control	(154)	3.0 ± 0.8a	3.1	4.2	4.2	2.3	2.9	3.3 ± 0.3a
120	(73)	2.7 ± 0.3a	2.8	2.8	1.9	3.0	3.0	2.7 ± 0.3a
80	(58)	4.5 ± 1.2a	4.0	4.0	4.1	5.5	4.8	4.5 ± 0.4a
40	(30) <sup>2</sup>	3.6 ± 0.6b	4.4	4.6	6.4	6.1	8.2	5.9 ± 0.6a
<i>Arnica cordifolia</i>								
Control	(154)	2.1 ± 0.2a	2.3	1.3	2.7	2.8	3.8	2.6 ± 0.4a
120	(73)	2.4 ± 0.7a	2.1	1.1	2.1	2.6	2.7	2.1 ± 0.3a
80	(58)	2.7 ± 1.0a	2.6	2.2	1.9	2.2	4.1	2.6 ± 0.3a
40	(30)	2.0 ± 0.5a	2.7	1.7	2.4	2.1	4.3	2.6 ± 0.3a



Table 4.—Percent understory cover of major species, before and after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado—Continued

Growth form, species, GSL, and basal area (ft <sup>2</sup> /acre)	Before thinning <sup>1</sup>	Years after thinning					Mean of 5 years after thinning <sup>1</sup>
		1	2	3	4	5	
<i>Lupinus argenteus</i>							
Control (154)	2.0 ± 0.5a	2.1	1.0	2.0	2.4	2.5	2.0 ± 0.3a
120 (73) <sup>2</sup>	1.3 ± 0.4a	1.3	1.9	2.2	2.8	2.6	2.2 ± 0.4a
80 (58) <sup>2</sup>	1.3 ± 0.5b	3.0	3.0	1.9	2.8	3.6	2.9 ± 0.4a
40 (30) <sup>2</sup>	1.1 ± 0.4b	2.8	3.5	4.5	5.8	6.2	4.6 ± 0.5a
<i>Solidago decumbens</i>							
Control (154)	0.9 ± 0.4a	1.7	1.0	0.4	1.0	1.2	1.1 ± 0.2a
120 (73)	0.6 ± 0.2a	0.7	0.2	0.2	0.1	1.1	0.5 ± 0.1a
80 (58)	0.4 ± 0.2a	0.4	0.5	1.3	0.7	1.8	0.9 ± 0.2a
40 (30)	1.9 ± 0.5a	1.8	1.9	1.9	1.1	2.5	1.8 ± 0.2a
<i>Epilobium angustifolium</i>							
Control (154)	1.0 ± 0.4a	1.1	0.9	1.0	0.9	1.5	1.1 ± 0.2a
120 (73)	0.6 ± 0.1a	0.5	0.7	1.4	1.0	0.7	0.9 ± 0.2a
80 (58)	0.7 ± 0.4a	1.8	1.3	1.4	1.4	1.0	1.4 ± 0.2a
40 (30)	1.4 ± 0.6a	1.4	1.1	1.2	3.2	1.6	1.7 ± 0.3a
<i>Cirsium</i> sp.							
Control (154)	0.6 ± 0.2a	1.1	0.7	0.9	0.8	1.2	0.9 ± 0.2a
120 (73)	0.5 ± 0.3a	0.8	0.9	0.5	0.4	0.4	0.6 ± 0.1a
80 (58)	0.9 ± 0.4a	1.4	1.9	1.4	1.0	0.9	1.3 ± 0.3a
40 (30)	0.8 ± 0.4a	0.8	0.7	0.8	1.0	0.4	0.7 ± 0.1a
<i>Astragalus convallarius</i>							
Control (154)	0.5 ± 0.4a	1.3	0.5	0.8	0.4	1.1	0.8 ± 0.2a
120 (73)	0.3 ± 0.2a	0.7	0.3	0.4	0.4	0.6	0.5 ± 0.1a
80 (58)	1.7 ± 0.7a	2.4	2.5	3.4	2.6	1.9	2.6 ± 0.4a
40 (30)	2.2 ± 1.0a	1.9	2.2	3.1	1.4	2.0	2.1 ± 0.4a
<i>Campanula rotundifolia</i>							
Control (154)	0.2 ± 0.1a	0.3	0.2	0.5	0.4	0.2	0.3 ± 0.1a
120 (73)	0.2 ± 0.1a	0.2	0.4	0.1	0.3	0.4	0.3 ± 0.1a
80 (58)	0.2 ± 0.1a	0.2	0.4	0.5	0.4	0.3	0.4 ± 0.1a
40 (30)	0.3 ± 0.1a	0.1	0.9	0.8	0.2	0.2	0.5 ± 0.1a

<sup>1</sup>Within growth form, species, and GSL values, before and after thinning followed by the same letter are not significantly different ( $P = 0.05$ ).

<sup>2</sup>Cover is significantly correlated with years after thinning ( $P = 0.05$ ).

in 16-year-old lodgepole pine in northern Utah. All of these authors found increased understory production as basal area stocking declined.

In this study, the more intensive levels of thinning, GSL 40 and 80, resulted in greater overall understory production than no treatment or GSL 120. These gains after thinning were mainly among herbaceous plants and amounted to +50% and +37%, respectively, at GSL 40 and 80. Year-to-year variations in production were noted in the less intensive treatments; but increases were consistent among all growth forms at GSL 40.

Although actual increments of understory gains after treatment were relatively modest through the first 5 years, the trends established then suggested that substantial further gains could be expected. Data also indicated that continued increases in herbivore activity and forage utilization was likely on the thinned blocks.

All understory plant species were perennials, with woody species comprising more than one-half of the plant production and 35% of the total number of species

present before treatment. Thinning to GSL 40 resulted in a marked decline in the average woody plant production and a concomitant increase in the proportion of forbs.

Except for losses in cover of *Vaccinium* spp. at GSL 40, no other major declines of individual species were detected during the study. Among all treatments, species increasing from one or more thinning levels included *Carex* spp., *Poa pratensis*, *Fragaria ovalis*, and *Lupinus argenteus*. Other gains in cover of herbaceous species resulted mainly from an accumulation of small increases among most forbs. Only three species, *Calamagrostis canadensis*, *Trisetum spicatum*, and *Deschampsia* sp., all grasses, were present after, but not before thinning, and only on GSL 40 and 80 blocks. Including these three, graminoids made up 21% of the total number of species present, and forbs comprised 44% of the total number of species enumerated during understory inventories. Among all treatments, no species present before thinning was absent afterward.

Table 5.—Characteristics of understory vegetation after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.

Characteristics, GSL, and basal area (ft <sup>2</sup> /acre)	Years after thinning					Mean of 5 years after thinning <sup>1</sup>
	1	2	3	4	5	
Moisture (percent)						
Control (154)	57a	60a	58a	60a	62a	59 ± 1
120 (73)	59a	60a	58a	62a	63a	60 ± 2
80 (58) <sup>2</sup>	65a	65a	67a	67a	68a	66 ± 1
40 (30) <sup>2</sup>	63a	68ab	67ab	69ab	72b	68 ± 1
Crude protein						
Control (154)	9.9a	8.4a	8.8a	10.3a	10.3a	9.5 ± 0.4
120 (73)	8.3a	8.3a	9.2a	10.7a	9.4a	9.2 ± 0.4
80 (58) <sup>2</sup>	9.8a	9.9a	9.6a	11.8ab	12.2a	10.7 ± 0.4
40 (30) <sup>2</sup>	10.2c	10.4c	11.4b	11.4b	13.6a	11.4 ± 0.5
Digestibility						
Control (154)	35.3a	38.8a	37.8a	40.7a	39.3a	38 ± 1
120 (73)	36.6a	35.5a	35.7a	37.2a	35.4a	36 ± 1
80 (58) <sup>2</sup>	45.6a	49.1a	46.6a	50.3a	51.7a	49 ± 2
40 (30) <sup>2</sup>	42.9b	51.1ab	58.7ab	56.3ab	60.2a	54 ± 2

<sup>1</sup>Within characteristics and GSL levels, means ± SE followed by the same letter are not significantly different ( $P = 0.05$ ).

<sup>2</sup>Characteristic is significantly correlated with years after thinning ( $P = 0.05$ ).

Table 6.—Mean frequency of plant browsing in the third, fourth, and fifth years after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.

GSL and basal area (ft <sup>2</sup> /acre)	Growth form			All forms <sup>1</sup>
	Woody plants	Graminoids	Forbs	
Percent				
Control (154)	3.0	2.3	6.1	7.5 ± 2.8b
120 (73)	4.8	2.2	5.5	7.5 ± 1.6b
80 (58)	5.0	8.3	8.1	12.1 ± 2.3ab
40 (30)	6.4	13.3	16.1	19.3 ± 3.0a
All GSL <sup>1</sup>	4.8 ± 1.1b	6.0 ± 2.0ab	9.2 ± 1.4a	

<sup>1</sup>Means ± SE followed by the same letter are not significantly different ( $P = 0.05$ ). Values are not means of respective columns or rows because browsing sometimes occurred on more than one growth form in the same inventory plot.

Incidence of herbivore utilization of understory plants was relatively low, even in the favored GSL 40 blocks. Wallmo et al. (1972) enumerated species eaten and preferred by deer on uncut and clearcut areas on the Fool Creek watershed, about 4 miles from this study area, and 2,000 feet higher in elevation. Some of the same species occurred on both sites; but the understory complex there was very different from that on the thinning area. Although no differentiation of browsing among herbivores could be made, it is likely that cattle were the major users of forage on this study area.

As stated earlier, evidence of herbivore activity was virtually nonexistent before, and in the first years after thinning. The untreated stands not only contained relatively little, low quality forage, but in some areas

were stocked densely enough to preclude easy access by livestock. Increased activity, indexed by numbers of fecal groups, and higher incidence of browsed plants suggests that the thinning treatments were beneficial to these animals.

## CONCLUSIONS

Thinning 65-year-old lodgepole pine to relatively wide spacing resulted in increased forage production, quality, and availability. Whether all of the treatment intensities will provide economic gains to offset treatment costs is uncertain. Considerable value in wood products was accrued as posts, poles, and firewood, and the dollar

Table 7.—Mean frequency of plant species utilization by herbivores in the third, fourth, and fifth years after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.

Species	Square-foot quadrats	
	Number occupied (total 1080)	Percent with browsing
<i>Rosa</i> sp.	213	19.7
<i>Carex geyeri</i>	74	15.8
<i>Campanula rotundifolia</i>	33	13.3
<i>Happlopappus parryi</i>	397	12.8
<i>Carex</i> spp.	33	12.1
<i>Erigeron</i> sp.	32	12.1
<i>Populus tremuloides</i>	35	11.4
<i>Bromus ciliatus</i>	33	7.4
<i>Taraxacum officinale</i>	41	6.3
<i>Cirsium</i> sp.	38	5.3
<i>Arctostaphylos uva-ursi</i>	40	4.5
<i>Vaccinium</i> spp.	623	4.2
<i>Shepherdia canadensis</i>	37	3.7
<i>Epilobium angustifolium</i>	95	3.5
<i>Arnica cordifolia</i>	119	0.8
<i>Lupinus argenteus</i>	161	0.6
<i>Fragaria ovalis</i>	235	0.0
<i>Juniperus communis</i>	41	0.0
<i>Solidago decumbens</i>	37	0.0

Table 8.—Numbers per acre of herbivore fecal groups in the third, fourth, and fifth years after thinning to control growing stock levels (GSL) in pole-sized lodgepole pine in central Colorado.

GSL and basal area (ft <sup>2</sup> /acre)	Years after thinning <sup>1</sup>								
	3	4	5	3	4	5	3	4	5
	----- Deer -----			----- Elk -----			----- Cattle -----		
Control (154)	8a	33a	25a	8a	17a	17a	17a	25a	33a
120 (73)	17a	17a	25a	8a	8a	17a	33a	50a	42a
80 (58)	25a	25a	25a	25a	17a	17a	25b	50ab	67a
40 (30)	17b	42ab	50a	17a	17a	17a	25b	50ab	75a

<sup>1</sup>Within species and GSL levels, means followed by the same letter are not significantly different ( $P = 0.05$ ).

value of the residual stands probably will increase, because trees in the thinned stands should be larger and of better quality than those in untreated stands at sawlog harvest. Whether more wood fiber will be produced is uncertain.

Further forage increases will be worth more only if domestic and/or wild herbivores utilize the increased production. This will occur only if demand for forage currently exists or can be created. In theory, such demand can be stimulated by increasing stocking rates of domestic livestock, but only if operators have capacity to feed more animals for 8 to 9 months each year, because most extensive stands of lodgepole pine in the central Rockies can only serve as summer range.

Wild herbivores face similar winter range limitations, and populations of elk and deer would be aided little by

the added forage produced by operational application of the treatments described here since summer range is currently abundant. In addition, it is clear that the more intensive GSL treatments provide little hiding or thermal cover for elk and deer, at least in the early years. How these open stands will develop to maturity is unknown. It is possible that a new understory tree stand might develop from seed, on the more heavily thinned blocks. Such development could greatly modify the open character of the treated stands.

Finally, there is some likelihood that the very minor aspen component scattered through the lodgepole stands may flourish and provide a new deciduous overstory habitat component that could result in expansion of the rather limited bird and small mammal communities now present.



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<p>Crouch, Glenn L. 1986. Effects of thinning pole-sized lodgepole pine on understory vegetation and large herbivore activity in central Colorado. USDA Forest Service Research Paper RM-268, 10 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.</p> <p>Thinning treatments to control growing stock levels (GSL) in a stand of 65-year-old lodgepole pine enhanced understory plant production, cover, and forage quality 5 years after treatment. Plant use and large herbivore activity also increased in the more heavily thinned blocks.</p> <p><b>Keywords:</b> Lodgepole pine, stocking levels, plant production, herbivore use</p>	<p>Crouch, Glenn L. 1986. Effects of thinning pole-sized lodgepole pine on understory vegetation and large herbivore activity in central Colorado. USDA Forest Service Research Paper RM-268, 10 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.</p> <p>Thinning treatments to control growing stock levels (GSL) in a stand of 65-year-old lodgepole pine enhanced understory plant production, cover, and forage quality 5 years after treatment. Plant use and large herbivore activity also increased in the more heavily thinned blocks.</p> <p><b>Keywords:</b> Lodgepole pine, stocking levels, plant production, herbivore use</p>
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Mountains



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## Rocky Mountain Forest and Range Experiment Station

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